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Atanas Chervenkov

Determination of Electrical Field in oil cable muff

ABSTRACT

Oil cable muff for trial of power cable at high voltage in laboratory conditions is considered. The purpose in this work is the distribution of electrical field in the cable muff and especially in the areas with particulars . The stationary electrical field by finite element method is investigated. Distribution of voltage and electrical strength is represented. The electrical field is non-homogeneous along the cable axis. The maximum values of the electrical strength are in the insulation around the end of the copper shield of the cable.

INTRODUCTION

In our country the power electrical cable of high voltage with different insulation are used. Pespective cables are these, which have the insulation of new synthetic materials. They are used at medium voltage MV - 10÷30 kV and high voltage HV - 100÷500 kV. The suitable cable muffs for power electrical cables in laboratory conditions are tested [1].

In this work oil cable muff for trial of power cable at medium and high voltage in laboratory conditions is considered.

In the engineering practice the simple methods for computantion and simulation of electrical field in power electrical cables are used [4], but they haven't sufficient precision.

In connection with this FEM for determination of electrical field in the oil cable muff is used.

The purpose in this work is the distribution of electrical field in the areas with particulars.

ELECTROMAGNETIC MODEL

Stationary electrical field in the cable muff is investigated.
The oil cable muff is represented in fig. 1

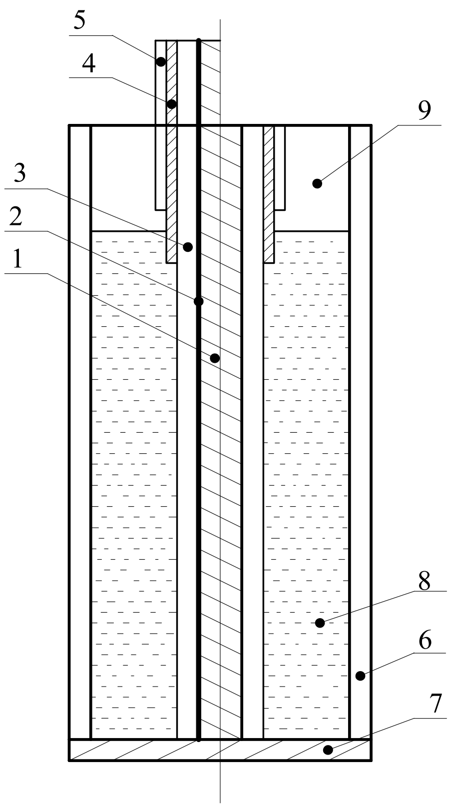

Figure 1. *Model of oil cable muff.*

In the figure 1 are indicated: 1-aluminium conductive core of the power cable; 2-shield of the cable core; 3- synthetic cable insulation; 4- copper shield of the cable; 5-synthetic envelope of the cable; 6-synthetic pipe of the muff, 7- metal cover of the muff; 8- oil; 9- air.

The resistance of cable conductive core is $\rho = 2.82.10^{-8}\ \Omega.m$. The permittivity and resistance of the cable insulation are $\varepsilon_r = 3.6$ and $\rho = 1.5.10^{13}\ \Omega.m$, respectively. The permittivity and resistance of the synthetic pipe are $\varepsilon_r = 2.26$ and $\rho = 0.85.10^{15}\ \Omega.m$, respectively. The permittivity and resistance of the oil is $\varepsilon_r = 2.1$ and, $\rho = 1.10^{12}\ \Omega.m$ respectively. The resistance of the cooper shield and the metal cover of the muff are $\rho = 1.725.10^{-8}\ \Omega.m$.

The electrical field in the space between the conductive cable core and the cover with electric scalar potential V is searched.

The investigated structure has symmetry because the cable and the oil muff are cylinders. Then the analysis in ¼ of investigated area can be limited.

In this case the Laplace's equation is [1]

(1) $$\frac{\partial^2 V}{\partial_2 x} + \frac{\partial^2 V}{\partial_2 y} = 0 .$$

The boundary conditions (Dirihlet conditions) are the potential values of the conductive core $V = 60000$ and the cable shield $V = 0$.

The electrical strength $\vec{E}$ can be presented as function of the scalar electrical potential V by equation [2]

(2) $$\vec{E} = -\nabla V$$

The analysis of electrical field is made numerically using finite element method FEM. In the case of finite element modeling the equation (2) has the description [3]

(3) $$\{E\} = -\nabla\{N\}^T\{V_e\},$$

where: $\{N\}$ are shape functions, $\{V_e\}$ is the scalar electrical potential in the nodes of finite element mesh.

RESULTS

The analysis of electrical field by FEM is made. On account of symmetry the problem is solved in the quarter of investigated structure.

The quadrilateral elements with four and eight nodes for the finite element mesh are used. The electric scalar potential method is implemented.

The distribution of electric scalar potential in the oil cable muff is represented on fig.2.

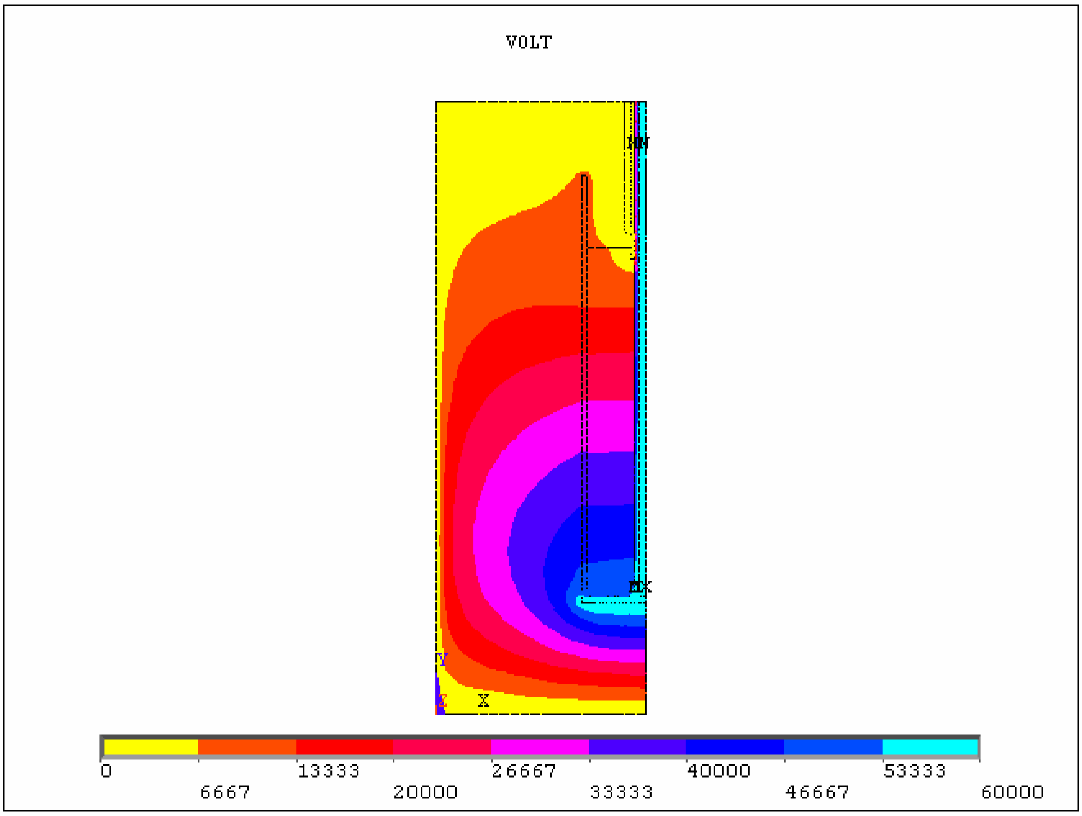

Figure 2. *Distribution of electric scalar potential in the oil cable muff*.

The field is non-homogeneous along the cable axis. The disturbance of homogeneity is in the interruption place of the copper cable shield and around the metal cover of muff.

The electrical strenght is first derived results from finite element modeling. The distribution of electric strenght in the oil cable muff is represented on fig.3.

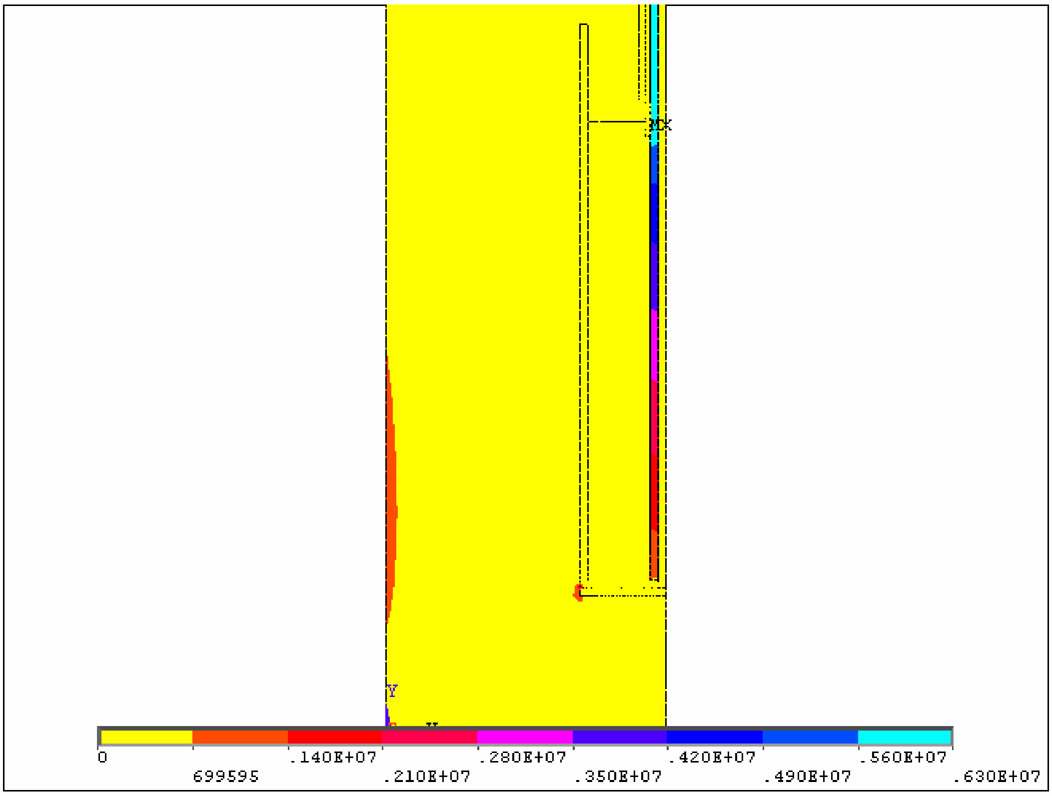

Figure 3. *Distribution of electric strenght.*

The distribution of the vectors of the electric strength in the oil cable muff is represented on fig.4.

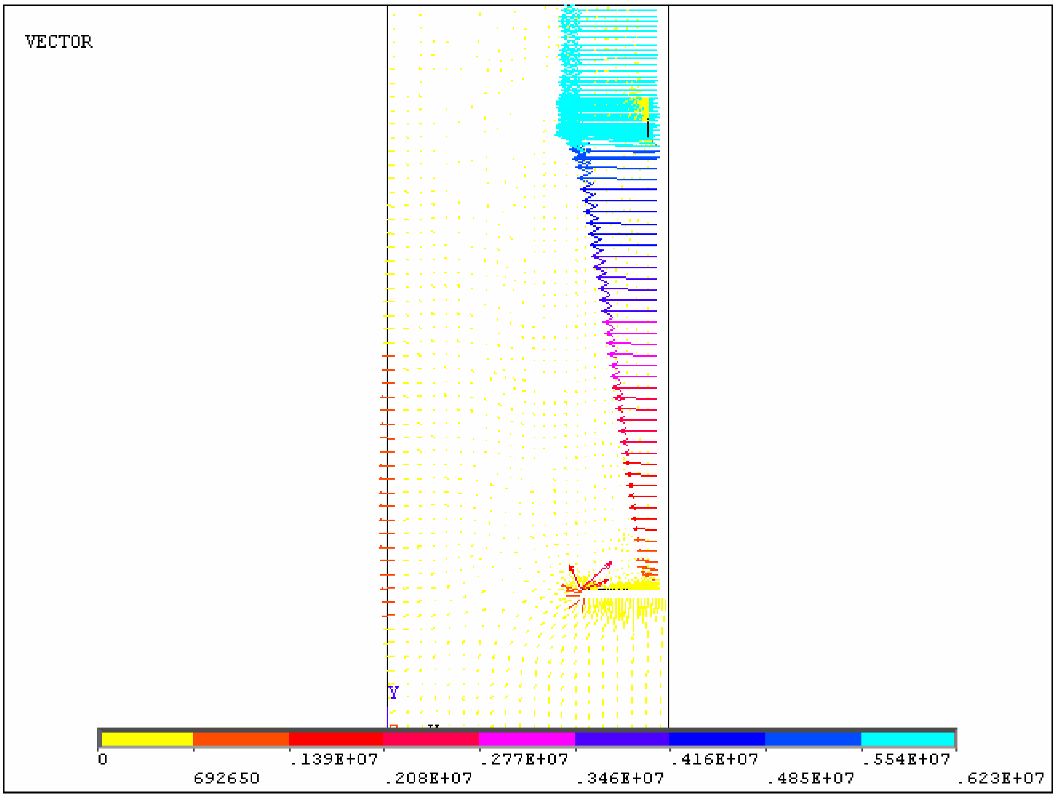

Figure 4. *Distribution of the vectors of the electric strength.*

Figure 4 presents the non-homogeneity of the electrical field in the cable insulation. The maximum values of the electrical strength are around the end of the copper shield of the cable. The values of the electrical strength are decreased in the end of cable insulation.

COMPARISON WITH CIRCUIT ANALYSIS

The obtained results with FEM are compared with results, which are obtained by modeling of circuit with distribution parameter.

We use the method described in [4].

The analysis of the electrical potentials is made numerically.

The results obtained for the electric scalar potential by circuit analysis in the oil cable muff is represented on fig.5.

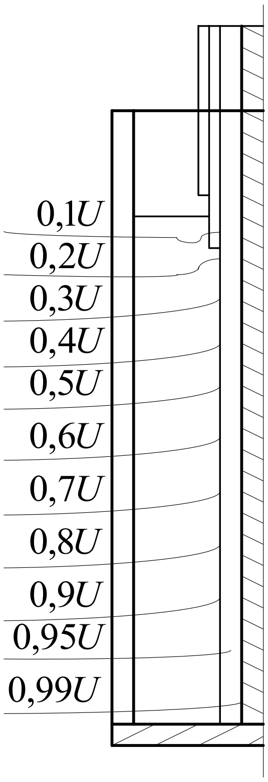

Figure 5. *Distribution of the electric scalar potential with circuit analysis.*

These results have the same character of voltage distribution in the investigated oil cable muff, but they can't display the peculiarity in the metal cover shield of the cable and the non-homogeneity of the electrical field.

CONCLUSION

- The electrical field in the oil cable muff is non-homogeneous along the cable axis.
- In some zones of the cable insulation, especially in the interruption place of the copper shield of the tested cable, the electrical strength values are higher than other. This situation can bring about partial charges in the cable insulation.
- FEM gives better results for electrical strength in peculiar areas of oily cable muff than the simple engineering methods, which are based on the circuit approach.

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